PATENT SPECIFICATION

DRAWINGS ATTACHED

1,132,605

1,132,605

Date of Application and filing Complete Specification: 29 Oct., 1965.
No. 39971/65.
Application made in United Arab Republic (No. 369) on 27 June, 1965.
Complete Specification Published: 6 Nov., 1968.

Index at acceptance: —G2 J(B7C11, B7M, B7X13)

Int. Cl.: —G 02 b 17/08

COMPLETE SPECIFICATION

New or Improved Optical System

I, MOHAMMED MOHEYDDEEN SHAFIK, of 5, Sharia ElHaddad, Kobri El Koubbah, Cairo, Egypt, United Arab Republic, a citizen of the United Arab Republic, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to a new or improved optical system having a particularly enhanced angle of view and utilizing an optical element which embodies the principle of deviation of rays as a result of reflection.

Compound lenses in general consist of a combination of simple lenses, of different forms and specifications, the variable factors of which enable a designer to compute and design them for optimum functioning within acceptable tolerances. For many successive generations this process has been adopted to produce different lenses, and lens systems having small or large angles of view. So far as large angles of view are concerned however a lens or lens system with an angle of view comparable to that of the human eye, with the simplest optical means, has not been achieved.

Within the last fifty years, attempts have been made to increase the angular range of some lenses and other optical devices especially in the field of photography and projection of still and motion pictures, used in entertainment, education and scientific research. Some devices such as cylindrical lenses or prismatic combinations, which increase the angular range of some lenses or optical devices in one plane to 1½ or twice the original angular sectors thereof, have been successfully accomplished. Such devices have been produced as additional attachments for regular lenses or as a part of a new device. However, the principal idea in both cases was to give an anamorphic effect and to ensure that the optical devices co-operating with one another achieve all the necessary corrections to yield optimum performance of the whole combination.

Furthermore, a recent cinematographic system has been developed using multiple synchronized apparatus both for making and showing a film. However the need for multiple lenses and films does create problems the most important of which are:

(a) the expense of the apparatus;

(b) difficulties and complications involved in the use of multiple films;

(c) as a consequence of (b) and variations in developing conditions, different parts of the total image may not be homogeneous in exposure;

(d) the existence of junction lines between parts of the projected image, together with possible vertical or horizontal displacements;

(e) difficulties due to breakage during projection of one component strip of the multiple films producing the total image.

The general object of this invention is to overcome *inter alia* the above mentioned difficulties and obtain a similar or somewhat similar result by using simple means that can be incorporated in any optical system for the photography, observation or projecting of a wide subject free of adjoining lines.

This optical means will be applicable with any existing optical system used in standard or substandard optical technics. The use of the invention may also permit shooting a scene on a given scale and projecting the same scene printed on a strip of film of another scale.

The invention may also provide an optical system adaptable for use with all regular apparatus employed in still or cine photography and thus permit the utilization of

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available regular processing and montaging methods and apparatus.

The present invention thus consists in an optical system comprising a concave paraboloidal, ellipsoidal or spherical wide angle "open" reflecting objective and a lens system whose axis is co-axial with the optical axis of the reflecting objective, or such axis as deviated by an intervening plane mirror, for forming an image in a plane perpendicular to the optical axis of the lens system of an object lying in a plane parallel to the optical axis of the reflecting objective.

By "wide angle" in this description and claims is to be understood any objective which when used for photography covers an image format whose diagonal is greater than its focal length. This is equivalent to a minimum semi-angular field of about 27°.

By "open" in this description and claims is meant a reflecting objective which in profile viewed along its optical axis is not a complete circle. It may have an irregular peripheral shape cut at random or it may be of regular form but sectioned in an axial plane in which case when used with a lens or other optical components it will have an angle of view of 180° in planes normal to its axis whereas in axial planes it will have an angle of view slightly or substantially less than 180°. This is in contrast to a so-called "closed" reflecting objective which is a section of a hollow closed body such as a sphere. If this objective is a section of a hollow sphere cut in any segmental plane it will have an angle of view of 360° in that plane and all other parallel planes, i.e. in all planes normal to its optical axis.

Advantages of an optical system according to the invention are:—

(a) that it gives an extreme wide angled image;

(b) freedom of image distortion (when the image is projected onto a surface of appropriate curvature);

(c) the extreme depth of field both for photography and projection; i.e. in photography once the optical system is adjusted to give a focussed image on the image surface then a universal focussing is achieved; i.e. focussing from the nearest distance to infinity. In case of reproduction once the optical system is adjusted in relation to the projected image to reproduce a sharply defined image on any surface; then the same image will be focussed on any other plane to any scale of reproduction.

(d) the uniformity of illumination of the projected image obviating the 4th power cosine factor.

For a better understanding of the invention, however, reference should be made to the following description of preferred embodiments thereof which are illustrated in the accompanying drawings. In these drawings:—

Figures 1, 2, 3 and 4 respectively illustrate four different concave mirror elements showing two "closed" and two "open" mirrors, the "open" mirrors being for use in lens systems according to the invention, the reference letters 'A', "B", 'C' and 'D' indicating a first transverse section, a second transverse section 90° removed from the first one, a plan view and a perspective view respectively.

The main principle on which the present invention is based is the utilisation of the property of deviation of rays as a result of reflection thereof from a concave "open" (as defined) reflective surface of special form and disposition in relation to a lens system.

Figure 1 of the drawings illustrates a "closed" spherical mirror. The various parts of Figure 2 of the drawings however show a part-spherical regular open mirror. Such a mirror may be sectioned in any axial or non-axial plane or planes; it may be sufficient to obscure certain parts of the mirror if there is no need to remove the certain obscured parts to admit light.

In all such cases the angle of view would be less than 360° in planes normal to the axis. However in axial planes it will embrace an angle of view slightly or substantially less than 180° in the sectors opposite the open parts of the mirror, or less than 90° in sectors opposite the non-open parts.

It is to be understood that in all instances the mirror must be sectioned in axial planes or planes parallel to the axis or partially obscured in these planes by an amount sufficient to cover exactly the desired sectors in the planes normal to the axis and it is also to be understood that this mirror must be sectioned in planes normal to the axis or partially obscured in these planes so as to be of sufficient axial depth to cover the desired sectors in axial planes.

It should further be noted that in order to obtain the desired increase of the angle of view of a lens used with the mirror, the lens must be placed so that the node of the said lens is at a distance from the surface of the mirror on the common axis more than twice the focal length of the mirror i.e. outside the centre of the spherical mirror.

The above discussion relates to different segments of spherical concave mirrors whether "closed" or "open," regular or irregular. However, the mirror may be paraboloidal or ellipsoidal.

Figures 3 and 4 show two aspherical forms of mirror. In Figure 3 there is shown a conical "closed" mirror, whilst Figure 4 shows an ellipsoidal open mirror.

It should be noted that in order to obtain the desired increase of the angular field of view in a plane parallel to the optical axis of the lens used with a mirror as shown in Figure 4, the said lens must be positioned so that the

node of the said lens coincides with the second node of the ellipse.

It is desirable that the aperture of the mirror section in all the above mentioned cases corresponds to the angle of view of the lens, mounting the mirror coaxially in the optical system, within acceptable tolerances, in order not to affect the aperture of the lens except within the least possible limits.

Optical systems incorporating concave mirrors, in accordance with this invention, of which illustrative examples have already been mentioned may be used for photography and observation and/or projection of pictures of still or moving subjects. In assembling a concave mirror with a lens to increase the angle of view thereof in a compound optical system according to this invention the whole assembly may be mounted within a metallic sealed shell or the like to permit usage of the whole assembly under various atmospheric conditions and under water and to maintain all the parts of the assembly in good condition.

The whole assembly of the optical system may be mounted in various manners, positions and designs including deviation of the optical axis in a special direction in one part of the assembly and in another direction in another part once or several times so that the deviation may be from 0 to maximum 180°. Furthermore the modes of assembly may include different positions for a convergent lens an optical device or other correcting optical components co-acting with the mirror.

In the detailed description with reference to the drawings which follows some reference letters and numerals will be used to denote similar parts in various Figures. In all the figures the sealed outside shell, which may be metallic or otherwise of the various optical elements and their different positions have been omitted for the sake of simplicity and for a better understanding of the performance of the various embodiments.

EXAMPLE 1

This example consists of two embodiments, shown in Figures *5a* and *5b*. In both embodiments a concave spherical mirror Md is used. The depth of the mirror Md in the embodiment shown in Figure *5a* and represented in the drawing by arrows Ar is less than the radius of the sphere. It extends from point P_6 to point E_2, whereas in the embodiment shown in Figure *5b*, the mirror is sectioned in a plane shown by E-P_1 normal to its axis, passing through the centre of the sphere E and is then sectioned in another plane normal to its axis, passing the line E_2-P_4 in order to constitute an open mirror. The depth of this last mirror is between point E-E_2 and is indicated in the drawing by arrow Ar_1. In the embodiment shown in Figure *5a*, the optical system covers in the axial planes an angle α, included between the top ray R_1 the uppermost point of which is at P_6, and ray R_2 which by-passes the body (not shown) of the optical apparatus. In the embodiment shown in Figure *5b*, the optical system covers in axial planes angle α, included between top ray R_1 the uppermost of which is at point P_4 and ray R_2, which is reflected at point P_4.

It is apparent that ray R_1 in Figure *5b* is higher than its corresponding ray R in Figure *5a* as a result of mirror Md in Figure *5b* being cut in a plane so as to pass line E_2-P_4. Similarly ray R_2 in Figure *5b* is higher than its corresponding ray R_2 in Figure *5a* as a result of cutting the mirror at point P_4. This system will cover a sector of 180° in planes normal to the optical axis of the system.

EXAMPLE 2

In this example which is illustrated in Figure 6, there is used an ellipsoidal concave open mirror Me. In this Figure rays are shown as ray beams, the ray beam R penetrates the shield Sh_1 and passes the first focus F_1, which coincides with point C_1 representing the centre of the sphere of the shield Sh_1. Said ray beam will then be reflected in area P_1 by the concave mirror Me to the second focus F_2, which coincides with area P_2, representing the aperture area of the lens and therefrom the beam strikes point P_3 on the image surface S.

In a similar manner ray beam R_2, by passing the body (not shown) of the optical apparatus, will produce an image of its source at point P_5 on the image surface S.

Thus it is apparent that in axial planes this optical system covers sector α, corresponding to angle β of the sector of the lens, whereas in planes normal to the axis it covers a sector of 180°.

EXAMPLE 3

This example relates to an embodiment shown in Figure 7 and representing a new optical system utilising two concave ellipsoidal open mirrors.

This unitary optical system consists of an ellipsoidal concave open mirror Me_1 whose first focus is F_1 and whose second focus F_2, and another mirror Me_2 of the same shape whose first focus is F'_1 and whose second focus lies at the same point F_2. These two mirrors are oppositely mounted, as shown in the Figure.

The system also comprises a lens L, the nodal point of which P_2 coincides with the common second focus F_2. It is preferable that the lens be of symmetrical form, in which case both mirrors Me_1 and Me_2 are identical.

However, both mirrors may be different and, in this case, the lens will be asymmetrical in form.

However, it is desired that the second foci of both mirrors shall coincide with the nodal point P_2 of the lens.

Finally, the optical system includes a sur-

face for the image, which may be cylindical, as shown in axial plan view X and in plan view normal to axis X′ or may be spherical as shown in axial plan view X_1 and in plan view normal to axis X'_1.

In this embodiment ray R, penetrating the optical system, passes focus F_1, and is reflected by the mirror Me_1 at point P_1, so as to pass the common second focus F_2 coincident with point P_2, instead of producing an image of its source at the image surface and giving a picture in the "initial stage," to be explained below.

This ray R penetrates the lens L and passes to mirror Me_2, which will reflect it at point P'_1. It will then pass focus F'_1 and strike the image surface X or X_1, giving an image of its source in the "final stage" at the point P_3. In a similar manner, ray R_2 will produce an image of its source in the "final stage" at point P_5 on the image surface X or X_1. Thus, on the cylindrical surface X there will be produced a real image of the source of rays.

On the image surface X, there may be placed a negative film or a positive film for projection of an image produced by this system, and by the use of a projection surface placed in front of mirror Me_1, as shown by the phantom projection surface Ph, this is possible whenever there is available a light condenser suitable for projecting such an image in the above mentioned conditions.

It is clear that this unitary optical system covers in axial planes a sector α, corresponding to an angle β of the sector of the lens, while in planes normal to the axis, it will cover a sector of 180°.

EXAMPLE 4

This embodiment, shown in Figure 8, is similar in principle to the embodiment shown in Figure 6 and discussed in Example 2, but differs therefrom in that the plane mirror M_3 is placed inclined on axis 1—1 at an angle δ of 45°, its right hand edge is shown in the Figure lies in a plane normal to the optical axis and causes the optical axis at that edge of the mirror to deviate at point G to the direction 2—2 normal to the direction 1—1 in such a manner as to permit photography observation or projection with this system in the usual conventional lateral direction.

This embodiment is at present considered the preferred one.

As a result of using plane mirror M_3 the lens and the optical apparatus K are placed on axis 2—2 at point P_2 in such a way that point P_2 coincides with F'_2, which is the image of the second focus F_2 of the ellipsoidal concave mirror Me, i.e. point F_2 shown in Figure 6 and not shown in Figure 8, which is the second focus of the mirror in the axis 1—1.

In this embodiment, ray R penetrates shield Sh_1 and passes the first focus F_1, coincident with point C, to be reflected by the concave mirror Me at point P_1 in the direction of the second focus F_2, it then strikes the plane mirror M_3 and is reflected thereby at point P_2b to point P_2, coincident with point F'_2, to reach the image surface S and produce an image of the source of this ray at point P_3. In a similar manner, an image of the source of ray R_2 is produced at point P_5. The ray R_2 may extend angularly to coincide with axis 1—1, as shown vertically in this Figure.

Thus, it is obvious that this optical system covers in an axial plane sector α, corresponding to angle β of the sector of the lens, whereas in a plane normal to the axis, it covers 180°, when there is no front shield for this system.

It is to be noted that if it is desired to obtain a system which covers, in planes normal to the axis, a sector as close as possible to 180° and a washer, a metallic shield or any similar article is mounted on the transparent shield Sh_1, such washer, metallic shield or the like, must be flat with the least possible thickness, since this thickness will be an obstacle to the rays in planes normal to the axis at both edges of the concave mirror and subtending an angle corresponding to the said thickness relative to the centre of the transparent shield Sh_1.

As described above a real image may be obtained in two stages.

These two stages may be carried out by a unitary integral optical system, e.g. by the system discussed in Example 3 and shown in Figure 7.

However, these two stages may be carried out by two similar systems, one for producing an initial image of which the dimensions are not on the same scale of reproduction either in axial planes or planes normal to the axis, with respect to the three planes of the actually photographed scene.

It is to be noted that the scale of reproduction increases in a direction from the centre of the picture towards the periphery thereof. Consequently the outlines lying on one circle of the picture will be on the same scale. This increase in scale is non-linear and differs in its non-linearity from one case to another depending on the type of concave mirror use, whether the latter is spherical or aspherical.

In the initial stage, when photographing or reproducing the image obtained in the initial stage and using an optical system, preferably a system similar to that used in obtaining the image in its initial stage, the image is projected on to the concave projection surface, which may be cylindrical as in the case of surface X, or spherical as in X_1 shown in Figure 11.

It is desired that the optical axis of the concave mirror of this embodiment shall coincide with the axis of curvature of the cylin-

drical projection surface, or shall pass the centre of the spherical projection surface.

In the light of the foregoing disclosure, it will be apparent to those skilled in the art that in any assembly of a complete optical system including the concave mirror according to this invention any optical device may serve as a correcting device among other necessary correcting devices for original and subsidiary aberrations. By the term "any device" it is intended that the optical system shall include all those elements necessary to contruct the system and which are placed in any position in the path of rays starting from the points that are being photographed or observed up to the image surface and *vice versa* in the case of projection. Such elements may be any optical elements in the path of the rays, such as lens elements or an optical device co-acting with the concave mirror of this invention, alternatively it may be a correcting device in the form of a lens stuck to the concave surface of the concave mirror, or a part of the said concave mirror, in which case it affects the rays twice, i.e. it refracts those rays when they pass through to the reflecting surface of the mirror and produces the same effect when such rays are reflected by the said surface. In this case, the reflecting coating layer of the mirror is applied to the convex surface of the said optical element. The correcting optical elements may be placed between the concave mirror and the lens, or placed between the said lens and the image surface or plane, in which case it may contact that plane.

Furthermore, a filter or filters may be placed in any position of value in the arrangement of correcting elements. The filter may be flat or half-spherical, in the latter case the filter must have a larger diameter than that of the transparent shield and be placed outside the said shield Sh_1.

It is to be noted that the surface on which still or motion pictures, taken by any system subject to the principle of this invention, are reproduced, should be concave. It may be either cylindrical or spherical and cut in dimensions which are in uniformity angularly with the sector of the reproduced photograph in its three spatial planes (the lateral, the vertical and in depth).

The designer of the proposed optical system may freely determine the value of the angle to be covered in the axial plane and divide the said whole angle as desired, so that the value of the angle below the line normal to the axis passing the nodal point of the concave mirror may be larger or smaller than half the whole angle.

Thus, the complete optical system will cover a non-symmetrical sector above and below the optical axis of the system, so that the angle of elevation may not be equal to the angle of depression, permitting special angles to be obtained which conform to the method of still or motion picture reproduction in theatres and are in accordance with the gradient of the floor and seating of the said theatres with the least possible modifications, since the projection apparatus used in such a system may be placed at the centre or at the axis of curvature of the screen in front of the audience. It may also be placed below the front row of the audience or suspended above them, in accordance with the selected angles and elevation.

If desired the proposed optical system may be used for photographing and reproducing the same picture with its relative dimensions unchanged or may be used with other optical systems of reproduction, which differ from the aforementioned optical system in their dimensions, or in the focal length of the lens included in the system, and consequently, in the dimensions of the concave mirror. However, in all conditions the two systems must be similar in the values of the corresponding angles of the parts of the scene in the three spatial dimensions either in photographing or in reproducing, i.e. the image both in the case of photographing and reproducing has to be at the same distance from the nodal point of the lens included in both systems when focussed for photographing or reproducing within the acceptable tolerances.

Several embodiments of this invention have been disclosed in the foregoing by way of example only.

It is apparent that certain modifications may be made within the scope of the invention as defined in the appended claims.

WHAT I CLAIM IS:—

1. An optical system comprising a concave paraboloidal ellipsoidal or spherical wide angle "open" reflecting objective and a lens system whose axis is co-axial with the optical axis of the reflecting objective, or of such axis as deviated by an intervening plane mirror, for forming an image in a plane perpendicular to the optical axis of the lens system of an object lying in a plane parallel to the optical axis of the reflecting objective.

2. An optical system as set forth in claim 1 in which the reflecting objective is a concave spherical mirror of lesser depth than the radius of the sphere.

3. An optical system as set forth in claim 1 in which the reflecting objective is a concave spherical mirror sectioned in a first plane normal to its axis passing through the centre of the sphere and also sectioned in a second plane normal to its axis.

4. An optical system as set forth in claim 1 in which the reflecting objective is an ellipsoidal concave mirror and the lens system is located with its aperture area at the second focus thereof for directing an image onto a plane reflective surface perpendicular to the optical axis.

5. An optical system as set forth in claim 1 in which the reflecting objective is an ellipsoidal concave mirror and comprising a second opposite mounted ellipsoidal mirror of which the second focus coincides with the second focus of the reflecting objective, said lens system having it nodal point coincident with said common second focus.

6. An optical system as set forth in claim 1 in which the reflecting objective is an ellipsoidal concave mirror and including a plane mirror disposed with one edge at or adjacent the optical axis of said reflecting objective at an angle of 45° to said axis to deviate said axis in a direction normal thereto, said lens system being situated on said deviated axis with its aperture area at the second focus of the reflecting objective.

7. An optical system substantially as hereinbefore described with reference to and as shown in any of Figures 5A, 5B, 6, 7 or 8 of the accompanying drawings.

MARKS & CLERK,
Chartered Patent Agents,
Agents for the Applicant.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1968.
Published by the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

1,132,605 COMPLETE SPECIFICATION

3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEET 1

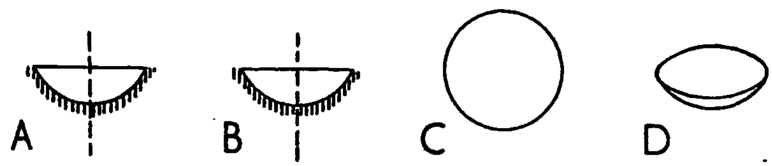


FIG. 1

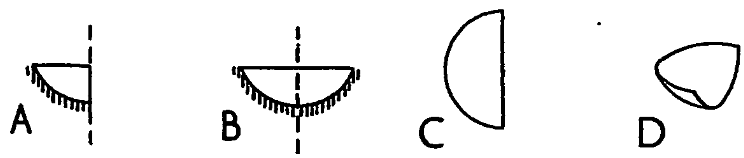


FIG. 2

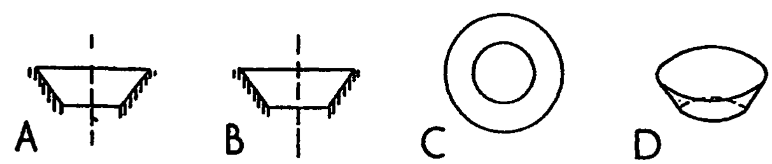


FIG. 3

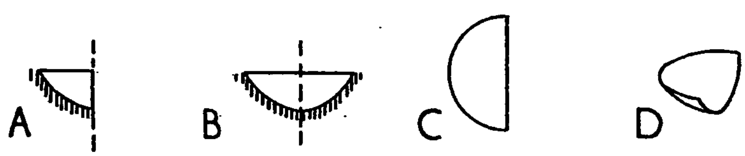
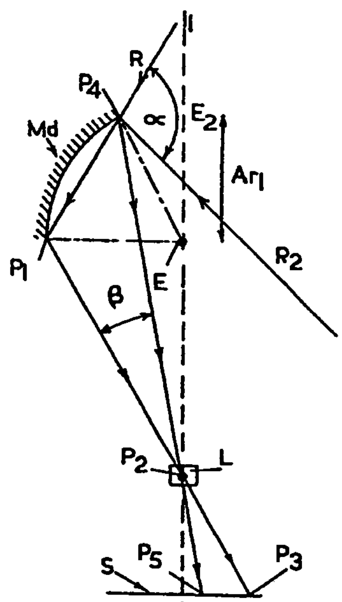


FIG. 4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P_4
Md
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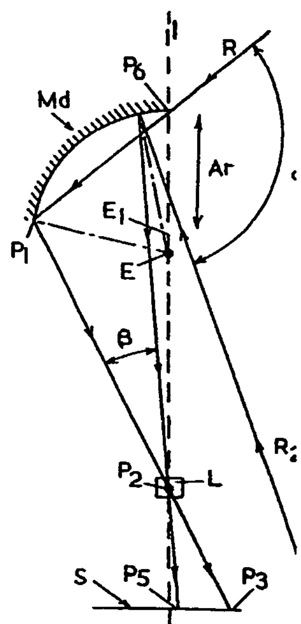
E_2
Ar_1
P_1
E
β
R_2
P_2
L
S
P_5
P_3
I

FIG.5B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P_1
E
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P_5
P_3

FIG.5A

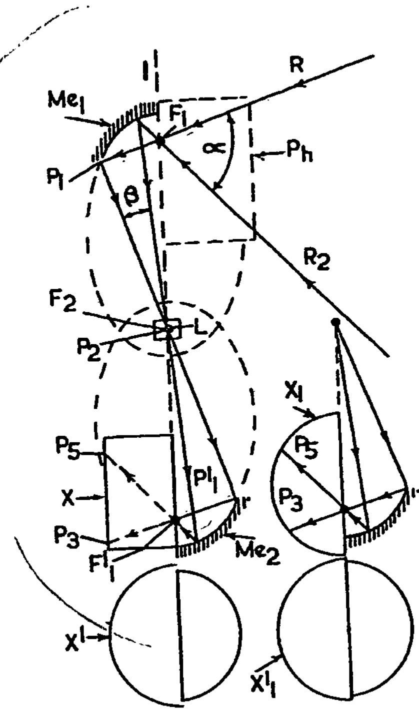

FIG.7.

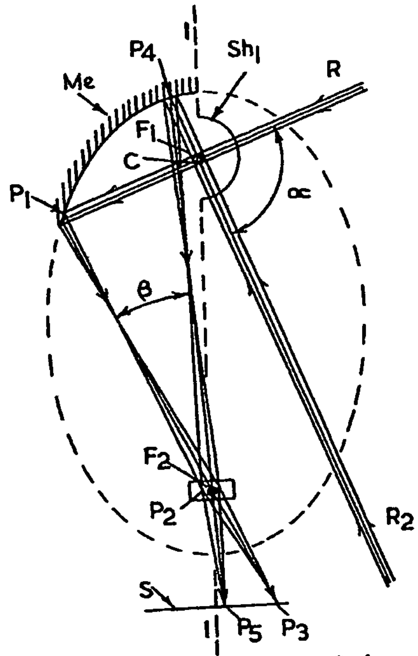

FIG.6.

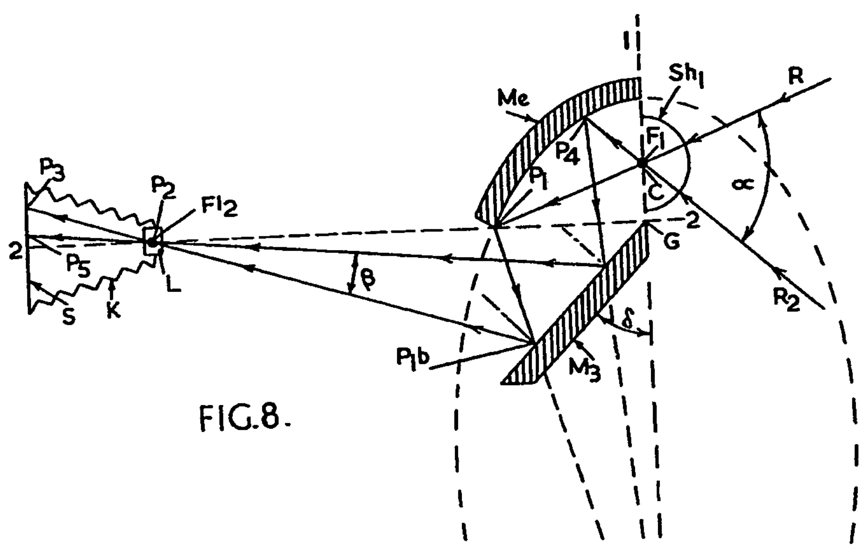

FIG.8.

1,132,605 COMPLETE SPECIFICATION
3 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 2 & 3

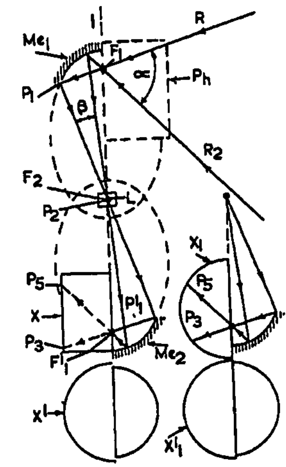

FIG.7.

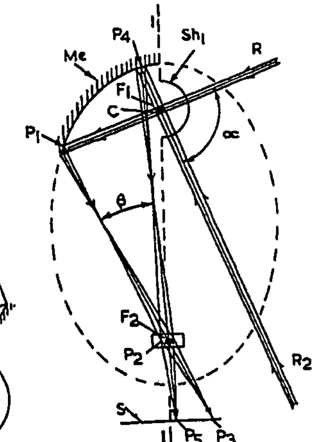

FIG.6.

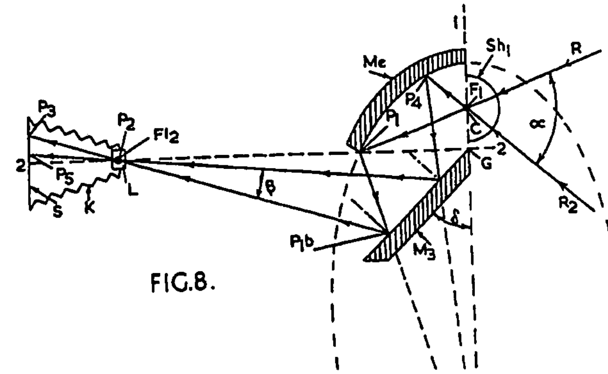

FIG.8.

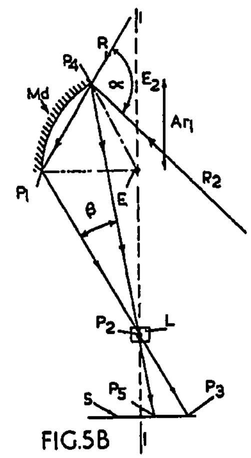

FIG.5B

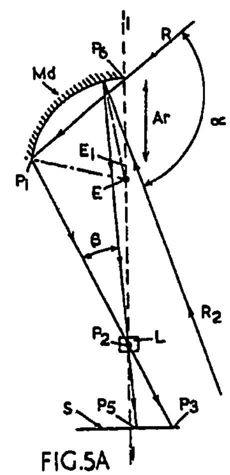

FIG.5A